YOUR MENTOR GURU

CSIR NET Life Sciences & Biotechnology — Unit 13

Methods in Biology

Study & revision companion | Topic explanations, core facts, and active-recall questions

How to use this guide

Read each topic, explain the key mechanism in your own words, then answer the self-check prompts without looking at the notes. Use your detailed textbook or class notes for full derivations and additional examples.

Topic overview

1. 1. Genome Editing and CRISPR
2. 2. Recombinant DNA and Synthetic Biology
3. 3. Vaccines and Therapeutic Biotechnology
4. 4. Stem Cells and Regenerative Medicine
5. 5. Agricultural Biotechnology
6. 6. Environmental and Marine Biotechnology
7. 7. Omics and Precision Biotechnology

1. Genome Editing and CRISPR

CRISPR–Cas9 targeting depends on guide RNA pairing and an appropriate PAM adjacent to the target.

Double-strand breaks can be repaired by NHEJ, often yielding indels, or HDR when a suitable donor template is available.

Base editors alter selected bases without requiring a conventional double-strand break in many designs.

Prime editing uses a reverse-transcriptase-linked system to write specified edits, with efficiency varying by target.

Vectors carry inserted DNA into hosts; promoters, origins and selection markers have distinct roles.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: selection does not verify insert orientation.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

2. Recombinant DNA and Synthetic Biology

Restriction enzymes recognize specific DNA sites; ligases join compatible DNA ends.

Expression vectors require suitable promoters, replication or integration features and selectable elements as appropriate.

Synthetic circuits combine sensors, regulatory modules and outputs to implement designed behaviors.

Standardization and biological context are major challenges to circuit predictability.

CRISPR systems guide nucleases or editors to selected targets; repair pathways determine outcomes.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: sequence confirmation is necessary to verify edits.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

3. Vaccines and Therapeutic Biotechnology

Recombinant subunit vaccines deliver defined antigens, often with adjuvants.

mRNA vaccines use cellular translation to produce an encoded antigen; formulation and stability affect delivery.

Monoclonal antibodies bind selected epitopes and may be engineered for effector functions or pharmacokinetics.

CAR-T cells are engineered to recognize selected antigens through synthetic receptors.

Sanger and high-throughput methods differ in throughput and read characteristics; RNA-seq measures transcripts.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: biological replication and sequencing depth solve

different problems.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

4. Stem Cells and Regenerative Medicine

Embryonic stem cells are pluripotent; induced pluripotent stem cells are reprogrammed from somatic cells.

Differentiation protocols use developmental signals to generate specified lineages.

Organoids model selected tissue features but often lack complete vasculature or mature organ-level functions.

Cell therapies require identity, potency, purity, safety and long-term monitoring.

Vaccines, monoclonal antibodies, molecular diagnostics and cell therapies use defined biological mechanisms.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: sensitivity and specificity differ from predictive values.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

5. Agricultural Biotechnology

Agrobacterium-mediated transformation and particle bombardment can introduce DNA into plant cells.

Marker-assisted selection tracks alleles linked to traits; genomic selection uses genome-wide marker information.

Gene stacking or pyramiding combines selected traits or resistance genes.

Genome-edited crops require assessment of edit identity, inheritance and potential off-target changes.

iPSCs are reprogrammed differentiated cells; organoids model selected tissue properties in 3D.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: organoids do not reproduce every feature of an organ.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

6. Environmental and Marine Biotechnology

Bioremediation uses organisms or enzymes to transform, immobilize or remove contaminants.

Phytoremediation uses plants and associated microbes for selected pollutants.

Wastewater treatment couples microbial carbon removal with nitrogen and phosphorus management.

Marine microbes provide diverse enzymes and metabolites adapted to unusual environmental conditions.

Transgenesis, cloning and tissue culture support research, breeding and conservation.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only

an association. The central distinction to retain is: insertion site can affect transgene expression.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

7. Omics and Precision Biotechnology

Single-cell RNA-seq resolves transcriptional heterogeneity that bulk RNA-seq averages across cells.

Proteomics identifies and quantifies proteins using separation and mass spectrometry workflows.

Metabolomics measures small molecules and is sensitive to sample handling and analytical conditions.

Multi-omics integration links molecular layers but needs appropriate statistics and independent validation.

Markers track traits during breeding; transgenic and edited crops require appropriate evaluation.

When solving a question, distinguish the underlying mechanism from its observable outcome. Compare the normal situation with the altered condition, and check whether the evidence supports a direct effect or only an association. The central distinction to retain is: linkage between marker and trait may be broken by recombination.

Self-check: Explain the mechanism or relationship above; identify one common misconception; predict the effect of changing a key variable.

Active-recall practice

1. Explain the essential principles of 1. Genome Editing and CRISPR and give one experimental or real-world application.

2. Explain the essential principles of 2. Recombinant DNA and Synthetic Biology and give one experimental or real-world application.

3. Explain the essential principles of 3. Vaccines and Therapeutic Biotechnology and give one experimental or real-world application.

4. Explain the essential principles of 4. Stem Cells and Regenerative Medicine and give one experimental or real-world application.

5. Explain the essential principles of 5. Agricultural Biotechnology and give one experimental or real-world application.

6. Explain the essential principles of 6. Environmental and Marine Biotechnology and give one experimental or real-world application.

7. Explain the essential principles of 7. Omics and Precision Biotechnology and give one experimental or real-world application.

Final revision checklist

- 1. Genome Editing and CRISPR
- 2. Recombinant DNA and Synthetic Biology
- 3. Vaccines and Therapeutic Biotechnology
- 4. Stem Cells and Regenerative Medicine
- 5. Agricultural Biotechnology
- 6. Environmental and Marine Biotechnology
- 7. Omics and Precision Biotechnology

Further study

Use the corresponding unit notes, topic-wise detailed lessons, MCQs, practice tests and full-length mock tests on yourmentorguru.com. This compact PDF is a revision companion, not a replacement for full syllabus textbooks.